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Effect of different doses of gamma rays on M_2 generation of turmeric

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Abstract
The study entitled "Effect of Different Doses of Gamma Rays on M_2 Generation of Turmeric" was conducted during Kharif 2024-25 at the Instructional Farm, Department of Vegetable Science, Dr. PDKV, Akola, using the turmeric variety PDKV Waigaon. The experiment was laid out in a Randomized Block Design (RBD) with five treatments (0, 10, 15, 20, and 25 Gy) of gamma irradiation and four replications. Observations were recorded on growth, disease incidence and yield attributes. Results revealed that increasing gamma ray doses exerted a suppressive effect on vegetative growth, as evidenced by reduced plant height, number of leaves and leaf area. However, moderate doses (15-20 Gy) improved yield-contributing traits such as number, length and diameter of finger rhizomes, as well as yield per plant, per plot and per hectare. The highest rhizome yield (26.32 t ha^{-1}) was recorded at 20 Gy, compared to 21.81 t ha^{-1} in the control. Further, gamma irradiation reduced the incidence of foliar diseases, with leaf spot minimized at 15 Gy (7.25%) and leaf blotch at 20 Gy (4.16%). These findings indicate that while higher doses (25 Gy) were detrimental to growth and yield, moderate doses, particularly 20 Gy, were effective in enhancing yield potential and disease tolerance in turmeric. Mutation breeding through gamma irradiation thus holds promise for inducing genetic variability and identifying superior mutants in clonally propagated crops like turmeric.

Keywords: Turmeric, gamma irradiation, mutation breeding, M_2 generation, yield traits, disease resistance, variability

Introduction

Turmeric (*Curcuma longa* L.) is an herbaceous perennial perennial, spice crop belonging to the family Zingiberaceae, widely cultivated in tropical and subtropical regions of the world. The total global production of turmeric is estimated at 11 lakh tonnes annually. According to Central Government 1st advance estimates, all India turmeric production in 2024-25 is at 11.16 lakh tonnes. Major turmeric producing states are Maharashtra, Tamil Nadu, Telangana, Karnataka, Madhya Pradesh, Odisha and West Bengal (Anon., 2025) [1]. The rhizomes, which constitute the economic part of the plant, are valued for their culinary, medicinal, and industrial applications. Curcumin, the principal bioactive compound, imparts the characteristic yellow color and is associated with antibacterial, antifungal, antioxidant, anti-inflammatory and anticancer properties. Despite its immense economic and therapeutic significance, turmeric remains a clonally propagated and sterile triploid crop (2n=63), which severely restricts genetic variability and limits the scope for conventional hybridization-based improvement.

Considering the narrow genetic base of turmeric and the increasing demand for improved varieties, mutation breeding offers a promising alternative for generating novel variability in such clonally propagated crops. Gamma irradiation, as a potent physical mutagen, has been successfully utilized in many crops to induce desirable mutations, leading to improvements in yield, quality and stress tolerance. In turmeric, however, systematic efforts to exploit induced mutagenesis have been limited and the M_2 generation is considered critical for identifying and selecting useful mutants. In view of the above fact, the present studies in turmeric M_2 generation were undertaken with objective of to study the impact of different doses of gamma rays on yield and yield-contributing traits.

Materials and Methods

The present investigation entitled "Effect of Different Doses of Gamma Rays on M_2 Generation of Turmeric" was conducted at the Instructional Farm, Department of Vegetable Science, Dr. PDKV, Akola during Kharif 2024-2025. The planting material consisted of rhizomes of turmeric variety PDKV Waigaon, belonging to the M_2 generation derived from gamma ray treatments presented in table 1. The experiment was laid out in a Randomized Block Design (RBD) with five treatments and four replications at a spacing of 30 × 30 × 90 cm on broad bed furrows in double row system. Data were recorded from five randomly selected plants per plot in each replication. The growth parameters studied included plant height (cm) at 120 DAP and 150 DAP, number of leaves per plant at 120 DAP and 150 DAP, leaf area (cm²) and disease incidence (%) for leaf blotch and leaf spot. The yield parameters recorded at harvest were weight and diameter of mother rhizomes, number and weight of finger rhizomes per plant, length and diameter of finger rhizomes, yield of finger rhizomes per plant (kg), yield of rhizomes per plot (kg) and yield of rhizomes per hectare (t). Data were analyzed using the statistically analysis as per Panse and Sukhatme (1967) [8]. Analysis of variance (ANOVA) was carried out to test the significance of treatment effects at the 5% probability level.

Table 1: Treatment Details for field experiment

Treatment	Details
T_1	Control
T_2	10 Gy (M_2 generation)
T_3	15 Gy (M_2 generation)
T_4	20 Gy (M_2 generation)
T_5	25 Gy (M_2 generation)

Results and Discussion

The data presented in Tables 2 and 3 show that different doses of gamma rays had a measurable effect on growth and yield-contributing parameters of turmeric in the M_2 generation.

Growth contributing parameters

Plant height at 120 and 150 days after planting progressively decreased with increasing gamma ray dose. The maximum height was recorded in the control (101.79 cm at 120 DAP; 105.49 cm at 150 DAP) followed by 10 Gy and 15 Gy, while the minimum was observed at 25 Gy (81.72 cm at 120 DAP; 84.43 cm at 150 DAP). This shows that higher doses of gamma rays suppressed vegetative growth. Similar reductions in plant height due to gamma irradiation have been reported by Raju *et al.* (1980) [9], Rao (1999) [11], Rashid *et al.* (2013) [12], Jayachandran (1989) [6] and Usha (2006) [15] in turmeric and ginger. At 120 and 150 DAP, the maximum number of leaves was recorded in the control (9.65 and 9.75, respectively), followed by 10 Gy (8.67 and 8.92), whereas the minimum was observed at 25 Gy (5.15 and 5.72). A dose-dependent reduction in leaf number was noted, indicating that higher doses retarded foliage development. These findings corroborate the observations of Hapsari *et al.* (2021) [4] in *Curcuma heyneana*, Ramakrishna (2006) [10] in turmeric and Jayachandran (1989) [6] in ginger who reported similar reductions in leaf production under increased gamma ray doses. Leaf area was highest in the control (442.0 cm²), followed by 10 Gy (414.25 cm²) and 15 Gy (376.0 cm²), whereas the lowest was observed at 20 Gy (304.50 cm²) and 25 Gy (324.25 cm²). These results indicate that moderate doses (10-15 Gy) maintained larger leaf areas, while higher doses suppressed leaf development. These findings agree with those of Ilyas and Naz (2014) [5], Ramakrishna (2006) [10] in turmeric and Taheri *et al.* (2016) [14] in *Curcuma alismatifolia.*

All gamma rays treatments recorded lower disease incidence compared to the control, indicating a suppressive effect of irradiation on foliar pathogens. The lowest leaf spot incidence was observed at 15 Gy (7.25%), whereas the lowest leaf blotch incidence was recorded at 20 Gy (4.16%), closely followed by 25 Gy. These findings suggest that moderate doses (10-15 Gy) reduced leaf spot, while higher doses (20-25 Gy) markedly reduced leaf blotch incidence, indicating the potential of gamma irradiation to help identify disease-tolerant lines. Similar trends of reduced foliar disease incidence under mutagenic treatments were reported by Ramakrishna (2006) [10] in turmeric and by Giridharan (1984) [3] in ginger.

Table 2: Effect of different doses gamma rays on growth parameters of turmeric in M_2 generation

Sr. No.	Treatment details	Plant height at 120 DAP (cm)	Plant height at 150 DAP (cm)	Number of leaves at 120 DAP	Number of leaves at 150 DAP	Leaf area (cm^2)	Leaf Spot (%)	Leaf Blotch (%)
1	T_1 Control	101.79	105.49	9.65	9.75	442.0	11.35	22.49
2	T_2 10 Gy	92.60	93.55	8.67	8.92	414.25	9	10.49
3	T_3 15 Gy	91.57	95.22	7.425	7.6	376.0	7.25	19.58
4	T_4 20 Gy	84.78	91.83	6.1	7.15	304.5	9.4	4.16
5	T_5 25 Gy	81.72	84.43	5.15	5.72	324.25	7.85	4.58
	F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG
	SE(m)±	3.1	1.8	0.1	0.2	18.6	0.2	1.6
	CD at 5%	9.5	5.4	0.4	0.7	57.3	0.7	4.9

Yield contributing parameters

The maximum weight of mother rhizomes per plant was observed in the control (35.30 g), which was statistically at par with 10 Gy (32.86 g) and 20 Gy (30.44 g), whereas the minimum weight was noted at 25 Gy (28.10 g). The diameter followed a similar trend, with the highest in control (3.55 cm) and lowest in 15 Gy (3.09 cm). These results indicate that moderate doses enhance rhizome development compared to higher doses. Similar findings were reported by Usha (2006) [15], Ramakrishna (2006) [10] and Madhuri *et al.* (2017) [7] in turmeric. The maximum number was recorded at 20 Gy, followed by 15 Gy (7.15) and 10 Gy (6.10), while the control (5.85) and 25 Gy (5.60) had the lowest values. This clearly shows that moderate doses, especially 20 Gy, enhanced finger rhizome production, whereas very high doses suppressed it. These observations are in agreement with Ramakrishna (2006) [10] and Usha (2006) [15]. The weight of finger rhizomes per plant was highest at 20 Gy (62.55 g), followed by 15 Gy (56.10 g) and 10 Gy (54.40 g), while the lowest was observed at 25 Gy (48.90 g) and in the control (51.60 g). This suggests that moderate doses of gamma rays (15-20 Gy) were beneficial for finger rhizome development. Similar results were reported by Ramakrishna (2006) [10] and Usha (2006) [15] in turmeric. The length of finger rhizomes is highest at t (20 Gy) 11.80 cm and lowest at (25 Gy) 9.85 cm. The diameter followed a similar trend, with the highest recorded at 20 Gy (2.35 cm) and the lowest at 25 Gy (1.92 cm). This indicates that 20 Gy improved the size of finger rhizomes compared to the control and higher doses. These findings are in line with those of Madhuri *et al.* (2017) [7] and Ramakrishna (2006) [10] in turmeric.

The yield of finger rhizomes per plant was maximum at 20 Gy (0.123 kg), followed by 15 Gy (0.111 kg) and 10 Gy (0.104 kg), while the minimum yield was recorded at 25 Gy (0.086 kg). The control recorded 0.095 kg per plant. This demonstrates that moderate doses, especially 20 Gy, produced superior yield of finger rhizomes per plant. These results agree with Usha (2006) [15], Jayachandran (1989) [6] and Ramakrishna (2006) [10]. The highest yield of rhizomes per plot was observed at 20 Gy (6.80 kg), followed by 15 Gy (6.15 kg) and 10 Gy (5.90 kg), whereas the control (5.65 kg) and 25 Gy (5.05 kg) recorded lower yields. This trend shows that 20 Gy induced beneficial changes that enhanced rhizome production. Similar findings were reported by Nandhini Devi and Chezhiyan (2007) [16] in turmeric. When converted to per hectare basis, the maximum rhizome yield was recorded at 20 Gy (26.32 t ha^{-1}), followed by 15 Gy (23.79 t ha^{-1}) and 10 Gy (22.79 t ha^{-1}). The minimum yield was recorded at 25 Gy (19.50 t ha^{-1}) compared to the control (21.81 t ha^{-1}). These results clearly indicate that moderate doses of gamma irradiation (15-20 Gy) can enhance the yield potential of turmeric compared to the control. These findings are supported by Nandhini Devi and Chezhiyan (2006) [16], Sharim and Shamsiah (2021) [13] and Anitta (2022) [2] who reported improved rhizome yields under moderate doses of gamma irradiation.

Table 3: Effect of different doses gamma rays on yield parameters of turmeric in M_2 generation

Sr. No.	Treatment Details	Weight of mother rhizomes $plant^{-1}$ (g)	Diameter of mother rhizome $plant^{-1}$ (cm)	No. of finger rhizomes $plant^{-1}$	Weight of finger rhizomes (g)	Length of finger rhizomes (cm)	Diameter of finger rhizomes (cm)	Finger rhizomes yield $plant^{-1}$ (kg)	Rhizomes yield $plot^{-1}$ (kg).	Rhizomes yield ha^{-1} (t)
1	T_1 Control	35.30	3.55	5.85	167.5	6.51	2.23	10.05	12.08	10.67
2	T_2 10 Gy	32.86	3.52	6.1	67.1	4.62	1.79	4.02	5.7	5.03
3	T_3 15 Gy	29.99	3.09	7.15	112.35	5.37	2.08	6.74	8.55	7.55
4	T_4 20 Gy	30.44	3.32	9.5	272.02	5.93	2.11	16.37	18.39	16.87
5	T_5 25 Gy	28.10	3.31	5.6	48.11	4.09	1.69	2.88	4.74	4.05
	F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
	SE(m)±	1.0	0.0	0.2	1.5	0.1	0.0	0.3	0.2	0.3
	CD at 5%	3.1	0.1	0.5	4.7	0.3	0.1	7.0	0.5	0.8

Conclusion

From the above results it is evident that gamma irradiation influenced both growth and yield-contributing characters of turmeric in the M_2 generation. Moderate doses of gamma rays, especially 15-20 Gy, were found to be more effective than the control and higher doses in improving key parameters such as plant height, number of leaves, leaf area, weight and size of rhizomes and overall yield per plant and per hectare. In contrast, higher doses like 25 Gy generally caused a reduction in growth and yield attributes. These findings clearly indicate that controlled mutagenesis through gamma irradiation at moderate doses can serve as a useful tool for inducing favorable changes and enhancing the yield potential of turmeric.

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